SILVICULTURAL VIEWS ON THE CANADIAN SPRUCE FORESTS

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The forest classification for Canada as formulated originally by Halliday and revised by Rowe (1959) probably serves as the best geographical basis for discussion. The Canadian spruce forest may be interpreted to mean any Canadian forest with a dominant spruce component. Whereas it is true that spruce stands may occur in a majority of the eight forest regions included in Rowe's treatment, most readers will probably agree that the principal areas involved in the designation are part of the Boreal Forest Region. Most of its high elevation ecological counterpart, the Sub-alpine Forest Region, and also the closely related northern portions of the Montane Forest Region in the Prince George area of British Columbia may be included. On the other hand, easterners may wish to include those parts of the Great Lakes - St. Lawrence Forest Region and the Acadian Forest Region in which spruce-balsam forest types are of major importance. However, these rather vague definitions would still permit the exclusion of the rather limited areas dominated by Sitka spruce in the Coast Forest Region of British Columbia. This comparatively small area has a much more favorable climate for timber growth than the Boreal Forest Region and Sitka spruce is a minor component of the forest. It may be worth pointing out that silviculturally, species of spruce behave very differently and that economically, white spruce is most important in central and western Canada, black spruce is most significant in the eastern part of the country, especially in Quebec, whereas red spruce is of importance primarily in the Maritimes. In British Columbia and Alberta, Engelmann spruce (*Picea Engelmannii* (Parry) Engelm.) is quite important, particularly in the Subalpine Forest Region. The silvical characteristics of white, black, red, and Engelmann spruce have been published recently in summary form by Nienstaedt (1957), Heinselman (1957), Hart (1959a) and Alexander (1958a) respectively. An excellent systematic treatment of the genus *Picea* of interest to all Canadian foresters is that of Jonathan Wright (1955). Ronco (1961) has provided recently a valuable bibliography for Engelmann spruce. Since either balsam fir (*Abies balsamea* (L.) Mill) or subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) are almost constant associates of the spruces in boreal Canada, they need to be included in any discussion. Their silvical characteristics have been summarized recently by Hart (1959b) and Alexander (1958b) respectively.

Wright (1959) in discussing the Canadian spruce forest quoted figures for spruce yields in the British Isles of 220 cubic feet per acre per year and in Germany of 175 cubic feet per acre per year. This is misleading if it were meant to imply that we can hope to approach these yields in the Boreal Forest Region of Canada at least, which surely comprises the bulk of the Canadian Spruce Forest. Although one cannot be certain from

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his paper, it is probable that these yields refer to plantations of Sitka and Norway spruce respectively, and at least in the former instance, the climate would more nearly represent that of coastal British Columbia than of the Boreal Forest or adjacent regions of eastern Canada. On the other hand, the several figures suggested by Wright (1959) for average spruce yields to be expected in Canada (20-40 cubic feet or an average of 30 cubic feet per acre per year) seem reasonable although (except for parts of British Columbia and Alberta) they may be a bit optimistic. Certainly these figures were adequately qualified, and some substantiation may be found in the papers by Barnes (1937), Bickerstaff (1954), Fligg (1960), Fraser and Alexander (1949), Koroleff et al. (1951), Lafond (1958b), MacLean (1960), MacLean and Bedell (1955), MacLeod and Blyth (1955), Meyer (1929), Pike (1955), Pogue (1960), Ray (1956), Recknagel (1960), Taylor and Klein (1953) and Wilton (1959).

It has been suggested (Wright 1959) that assuming certain average yields and areas, the great spruce forest in Canada is being greatly undercut. This thesis stresses the urgency for increasing the cut in the spruce forest and presents the pleasant prospect that the imbalance between sawtimber growth and drain in the United States (Forest Service, U.S.D.A. 1958) may provide a continuing outlet for Canadian spruce lumber. It is true that so far as total wood fibre volume is concerned, species of spruce provide an overwhelming proportion of the volume of wood resources in the country (Canada Department of N.A. etc. 1957). If Best's (1960) optimistic prospects for Canadian forest industry are to become a reality, we will need to pay more than lip service to silviculture in the spruce stands of the country.

Whereas it is certainly true that there is much overmature timber in the Canadian Spruce Forest, the restraint of many government foresters is justified if we are to avoid overly-enthusiastic liquidation of the prime spruce sawtimber and to prevent the accumulation of further large acreages of non-productive cut-over lands. Such areas in parts of eastern Canada have been aptly termed "silvicultural slums" (Kennedy 1953). The unsatisfactory conditions in much of the Canadian Spruce Forest with respect to regeneration have been pointed out by such authors as Candy (1951), Hosie (1953 & 1954), MacLean (1959), Pepler (1953) and others. Kennedy (1953) noted that our next crop should be provided for from the profits made from cutting our virgin stands. Smith (1960) in an editorial in *The Forestry Chronicle* deplored the tendency to neglect reforestation problems in Canada. Even in the west, at this comparatively early date in the exploitation of the Canadian Spruce Forest, there is an accumulation of non-stocked or under-stocked land on good quality sites (Siburn 1960). Little will be gained by harvesting stands of "no-net-growth" if all we can produce in their place is brush or grossly understocked stands of "inferior" (or at least currently less valuable) species, particularly on the very best sites. Many "mature" and certainly a majority of the "immature" spruce timber types are probably growing as much as a large percentage of *some* of our spruce and spruce-balsam cut-over lands. We cannot afford to continue the high-grading of the best spruce stands for lumber in B.C. for example, and to watch passively while there

develops here what has already occurred to a deplorable degree in the Coast Forest (Ker, Smith and Little, 1960).

The creaming of the choicest remaining merchantable saw-timber stands without a more serious consideration of forest fire control and of regeneration and without aggressive action to correct our failings, is a process Canadian foresters must no longer tolerate.

The drawing of historical parallels, or attempts at such, may be fraught with peril, but it may be worth the risk for emphasis. For example, it may be instructive to recall what happened in Michigan, Wisconsin, and in Minnesota not so many decades ago. True, it was not in the Boreal or Spruce Forest in the true sense, and little good may come of course from merely "viewing with alarm." Nevertheless, we need not repeat mistakes indefinitely. The loss of productivity through repeated fires after logging and unwise land clearing and the resulting changes from white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) growing stock to other species on large areas must have been very great. True, in time, valuable stands of jack pine and aspen (*Populus tremuloides* Michx.) replaced these other species and industry has adapted itself to them, but does anyone seriously doubt that by and large the other species would probably have produced more valuable crops if they could have been maintained? To what extent are we passively, or under pressure from current forest economic policy, permitting this sort of history to repeat itself in the Boreal Forest of Canada? Should we sit by apathetically and let brush or secondary species replace the preferred spruce?

Logical, well planned development, aimed at harvesting the full present volumes of merchantable wood and designed to utilize the maximum growing capacity of this vast spruce forest is obviously desirable. However, it should be apparent that we are all too frequently failing in this aim—Bickerstaff (1954), Candy (1951), Hosie (1953 & 1954), Kennedy (1953), MacLean (1959) and Pepler (1953).

It is suggested therefore that, before an increased speed of liquidation of our choicest spruce timber is emphasized, better regeneration techniques must somehow be found and immediately put into force in spite of apparently overwhelming economic and political obstacles. Even more important, we must be certain we are not seriously reducing the productivity of our forest soils for an indefinite period by ill-considered logging methods or damaging fires, Ahlgren and Ahlgren (1960) and Lutz (1959 and 1960). As many authors have pointed out, the forest soil is the true "capital" on which our continued forest wealth essentially depends (Kennedy 1953, Rostlund in Haden - Guest *et al.* 1956). Soils in the Boreal Forest are often thin, stony, or cold and poorly drained. Once damaged by inappropriate management, the harsh northern climate does not permit rapid restoration to full productivity. Northern coniferous forest soils are discussed by Lutz and Chandler (1946), Wilde (1958) and particularly by Tamm (1950).

As a part of his interesting and colorful comparison of the Southern Pine Forest of the United States with the Canadian Spruce Forest, Wright (1959) selected for illustration the shortleaf pine (*Pinus echinata*, Mill.), quoting a yield for the species on good sites of 170 cubic feet per acre

per year. This is indeed high and shortleaf is the most widely distributed of the important southern pines. However, loblolly pine (*Pinus taeda* L.), an equally important species, can produce over 220 cubic feet per acre per year on the best sites (Schumacher and Coile 1960). On very short rotations for pulpwood, probably slash pine (*Pinus elliotii* Engelm.) could do even better and outproduce most Canadian spruce by a factor of two or three to one or better. In supporting his proposal for an accelerated harvest of mature and overmature Canadian spruce, Wright (1959, page 297) stated:

"In this connection, it is worth noting again that the southern pine forest is producing double the harvest of the Canadian spruce forest with only one fifth the volume of growing stock."

This may well be true, but it is probably no more a fact because Canadian spruce forests are undercut than because the southern pines can probably outgrow Canadian Boreal Forest spruce on a per acre basis by a wide margin. Lussier and Maheux (1959, page 19) pointed out that:

". . . we can only maintain our present stands by striving at once to reduce transformation and logging costs. Moreover, it would be erroneous to believe that this reduction can be achieved by lowering wages and by ruining our forests. Such a course of action could but fatally result in making us more vulnerable. This is a proven fact: the people of the South ruined their forests and weakened their economy so long as such methods were used. Their recovery occurred only after having earnestly put into practice scientific data and the findings of research. The same methods shall no doubt give us results equally satisfying. Such is the serious problem before our great forest industry today; its future rests on finding a solution."

Here in the Canadian Spruce Forest we are on very shaky ground indeed if we continue to neglect better silvicultural practices on the basis of economic expediency, since natural factors of climate and soil have favored the remarkable resurgence of the Southern Pine Forest. Nature is not so benign in most of Canada.

Stress is frequently put on the possibilities of planting in Canadian spruce forests in order to enable more use of clear-cutting methods (Wright 1959). It is granted that planting has a great deal to recommend it, *provided* there is a reasonable assurance of successful plantation establishment and growth on such sites, and that it is truly the most economical method in the long run. The ability to produce such successful plantations does not appear to have been demonstrated widely as yet over representative areas of the Canadian Spruce Forest. However, some good as well as poor results have been produced and a variety of work is under way, Bonner (1960), Cunningham (1953), Lafond (1958a), MacArthur (1957), Paine (1960), Silburn (1960) and Stiell (1958).

As recently as 1954, Hawley and Smith (1954, page 49) put it this way: "The American forestry profession must make considerable progress in both knowledge and technique before the inherent advantages of artificial regeneration can be fully obtained."

A great deal is said and written about planting in the South, and much is being done there, but White (1961) was quoted recently as follows with respect to planting in the South:

"Planting trees is considered a small fraction of regeneration, as 5 to 20 times more reproduction is established through natural means."

In other words, planting should not be proposed as a panacea for the logging problems of Canadian spruce forests. In this connection, neither more "clear-cutting" nor more "selection" should be flatly advocated as a generalization. To be sure, utilization is the key factor in any practical solution in many instances and, as many authors have noted, we need greater precision in our terminology, e.g. Place (1953). This is not the time to discuss utilization in any detail, but information pertinent to spruce has been brought out well in recent papers by Fensom (1959), Fogh (1957), Sonley (1957) and Wellwood (1960).

Spruce management has been rather thoroughly discussed in recent papers by Clark (1960), Heath (1959), Joergensen (1960), Johnson (1960a and 1960b), Lees (1960), MacLean (1960), Moss (1960), Silburn (1960) and Switzer (1960). In an editorial, Smith (1960) made appropriate comment on some of the problems faced in regeneration.

It may be trite to emphasize again that either true clear cutting or "apparent" clear cutting (i.e. the removal of an overwood from an accidental or natural "shelterwood"), or true "selection" or almost anything in between may be a great improvement over existing practice. However, this implies that some sort of plan, based on a much better understanding of ecological conditions and probable future stand development than is now available is not only prescribed, but actually carried out on the ground in the course of logging. Further, one cannot expect to find, let alone apply successfully such methods for such a large and varied region, unless a great deal more money is spent for research, extension, and in planning initial forest development—including road systems. Even so, it is not realistic to expect any classical regeneration system to work perfectly when it is superimposed on a decadent, overmature and totally untended stand. In another sense, no method can be successful unless more capital is invested in the next crop at the time of initial harvest. Too often, it would seem, the logger quite naturally only wishes to use the harvesting method which will produce the cheapest logs. When this legitimate goal is combined with the desire of governments controlling sale contracts to extract the maximum returns immediately in stumpage (and taxes) from frequently very low-quality crops, troubles are inevitable. A continuation of such compromises in cutting practices forced by economic considerations of the moment will doubtless continue to produce "silvicultural slums". Even where growing conditions are greatly superior to those of the Canadian Spruce Forest, capital for reforestation of land once covered with brush, even when rather favorably situated, does not seem to be available for the desirable restoration (Vaux 1954).

At this point a quotation from F. S. Baker (1934, page 5) is in order. The italics are mine.

"The great practical question of present-day silviculture therefore is not: How can ideal growing conditions and reproduction be secured in this forest? It is the reverse: If I do thus and so to the forest (dictated primarily on financial grounds), what will happen to forest reproduction and growth here? *If the results are too bad, some immediate profit will have to be sacrificed for future gain. The danger here lies in magnifying present limitations and under-rating both the chances of better financial returns in the future and the well-nigh irreparable injury that may be done to the future productivity of the forest by injudicious treatment.*

"The trends of stumpage prices are still certainly upward and will undoubtedly so continue for a long time, so that *expenditures for protection and silviculture should not be made merely upon the basis of present values and standards of utilization.* They are too conservative, although to what precise degree is most debatable."

This philosophy expressed by Baker appears to warrant consideration in viewing the silvicultural practices applied presently to Canadian Spruce stands. As foresters, we have more of an obligation than most to take the long view. Heiberg (1960) and Kennedy (1953) have made appropriate comments along this line. It would seem that Muelder (1959) was right when he said (page 325) "The main trouble in silviculture is that financially each generation can get along without it much more profitably than with it."

At the present time in much of the Canadian Spruce Forest "clear-cutting" is usually carried out on what amounts to a diameter limit basis, especially where no pulpwood market exists as in much of interior British Columbia. Under such utilization conditions, large volumes of waste wood ("left-overs" in the polite, modern usage) result. This is particularly true in the overmature stands containing high percentages of balsam or alpine fir. Some of the operators in British Columbia who have strenuously objected to what amounts to a fairly heavy selection cut using either a relatively high diameter limit or tree marking system, are sometimes finding themselves now "hoist on their own petard" when they have been granted a chance to in effect produce almost a true "clear-cut". With a lower diameter-limit specified in the contracts in order to avoid undue waste and to provide better chances for natural regeneration, they of course find themselves producing logs of low average diameter. This results naturally in high saw-milling costs (Ker 1959) which may cancel any real or fancied reductions in logging costs attributable to avoiding the "evils" of selection. Windfall losses are of course a key problem, but an adequate discussion of this is not possible here (Weetman 1957).

Method of cutting alone is only part of the picture. Seed bed preparation and other factors are also important. However, to discuss the problem of scarification and its correlation with seed crops as a necessary technique for most successful natural regeneration of spruce is beyond the scope of the present paper. The reader is referred to Crossly (1952), Holt (1955), Holt, Swan and Weetman (1956) Place (1955), MacLean (1959), and Smith (1955). However, the necessity for a certain amount of site preparation is not limited to natural regeneration but may be required for reasonably successful

direct seeding and planting on some sites. This must be recognized in any comparisons of relative costs.

Too often, planting is proposed as a last resort, or "surgical operation" in order to circumvent the inevitable frustrations and the investments necessary to achieve successful natural regeneration. To be sure it isn't easy, or indeed always possible at almost any price to find effective modifications in logging methods, especially when nature is uncooperative in the production of seed. It is even more difficult to make research results quickly known, adapted to the particular job and put into practice. Armson (1960b) has some sensible things to say in this connection. In addition, the real "squeeze" between operation costs, markets, and stumpage prices is not to be ignored, and may frustrate the best of intentions.

It is agreed that considering all the difficulties in trying to apply silvicultural methods aimed at natural regeneration to old, unmanaged stands, planting should be given a reasonable trial on a fairly large scale. Wright (1959, page 297) stated:

"Contrary to popular belief, planting is economical. It is prompt and adaptable and it permits more flexibility in logging plans."

This may be so, especially in many places other than the Boreal Forest, but at the present time particularly in western Canada, relatively little experience is available in operational scale planting and much more research and extensive trials are needed. Contrary to what some foresters seem to believe, good spruce planting stock is expensive to grow and is likely to be a considerable item in the total cost of planting. If planting is to be advocated as a widespread solution, even if for only the best quality sites, much more must be learned about how to grow high quality (physiologically) and inexpensive nursery stock of the best possible genetic constitution. Although much thought and effort have been given to this subject by many Canadian workers, it is doubtless not commensurate with the ultimate importance of the subject. It is true that provenance trials and breeding work are under way and these projects should be encouraged and expanded, as should nutritional and other physiological and ecological studies. Much more fundamental forest and nursery soil investigations will be called for if we seriously advocate a major spruce-planting program. Some of the pioneer workers and their published papers include the following: Armson (1960), Dickson, Leaf and Hosner (1960), Farrar (1948), Heimburger (1958), Holst (1955), Lafond (1958a) and Swan (1960).

Closely related to the problem of good quality planting stock is the selection of the best sites for planting. In planning for sustained yield and intensive forestry the productive sites must be easily identified at the start of the initial harvesting operations and road planning should be on the basis of a permanent forestry operation. Bickerstaff (1954) pointed out how present yields are often confused with inherent productivity. Site studies comprise a very important field and reflect a great variety of approaches. Barnes (1954), Brown (1956a), Fogh (1957) and Sonley (1957) discussed road planning or land use planning and for mountainous regions of the west, Silen (1955)

made valuable suggestions based on work done in the Douglas fir region. Site and related ecological studies in northern spruce forest regions which aimed at aiding either estimates of productivity or supplying guides to silvicultural methods or both were reported or discussed by Arnborg (1960), Brown (1956b), Farrar (1960), Heinselmann and Zasada (1955), Hills (1960), Krajina (1950), Lafond (1958b), Lutz and Caporaso (1958), Melekhov (1960), Raup (1953), Ray (1960), Rowe (1953), Rowe *et al.* (1960) and Sukachev (1928 and 1960). These and many other similar studies should prove at least as useful in the selection of planting sites as in other phases of forest management planning.

The assumption is sometimes made that sites where spruce grows now should also be producing spruce for the next rotation. This should not be accepted without question, since other species may produce a crop of equal or even greater value on the site concerned. For example, Arnborg (1960) has pointed out that in northern Scandinavia, Scots pine (*Pinus sylvestris* L.) can produce twice as much as spruce (*Picea abies* (L.) Karst) on dry to fresh sites. At Prince George, Heath (1959) called attention to the need in this region to consider the prospects of managing many of the northern British Columbia interior region sites primarily for the production of lodgepole pine crops. There is considerable local evidence (Fligg 1960) that this would be a logical development. Thiesmeyer (1953) in a more general discussion of Canadian forestry, expressed a somewhat similar philosophy when he wrote:

"The forester should put his skill to work on growing more useful fibre per acre and not worry too much about the particular species forestry will thus become a profession of people who learn more about Nature and humour her to bend her to their purposes."

It is possible that in many parts of the Canadian Spruce Forest, especially on the drier sites, either jack pine or lodgepole pine may produce more useful fibre per acre per year than any spruce species. This is of course more likely to be true if enough attention be given to the proper control of stand density at the time of regeneration cutting. Ultimately, if planting be indicated even for the pine sites on the better areas, the early application of forest genetics gives promise, since some time ago fertile hybrids were produced between jack and lodgepole pines (Righter and Stockwell 1949). To some this may be star-gazing indeed, but it isn't any too soon to start preparing for such eventualities (Farrar 1948 and Heimbürger 1958). Comparatively recent silvical summaries for jack and lodgepole pines are found in the work of Rudolph (1958), Tackle (1959) and Tackle and Crossley (1953).

In the same vein it will not do to neglect the silvicultural study of aspen and white birch (*Betula papyrifera* Marsh), (Hutnik and Cunningham 1961) especially from the forest soil viewpoint, along with other deciduous species. Not only do we need to know more of their silvicultural characteristics where we may be forced to accept them for the next rotation, but more knowledge of their physiology would facilitate controlling them where they are considered weeds. The potential value of mixed-stand growth once hardwoods can be more fully utilized has been noted by several authors, among

them Bickerstaff (1954) and Fogh (1957). Empirical yield tables for British Columbia (Fligg 1960) show greater yields for some mixed than for pure forest types.

In parts of eastern Canada balsam fir is one of the most productive species and lends itself particularly well to intensive management under the selection method. Where it grows in mixture with spruces it may well increase the total yield.

Finally, much more consideration should be directed by "wood production" foresters to the existence of other concepts of forest land use, particularly with respect to the more remote portions of the Canadian Spruce Forest. These still-wild areas are assuming increasingly important values for special forms of recreational use, as areas of retreat for the dense populations to the southward. Their value in this sense cannot help but grow at an accelerating pace. Taylor and Edwards (1960) stressed the importance of these less tangible values in relation to an area in British Columbia where spruce-balsam forest types are represented. In many regions, some aspects of recreational use may be perfectly compatible with forest management aimed principally at pulpwood or sawlog production; elsewhere, parks and wilderness-area needs may preclude most conventional methods of timber harvest over appreciable acreages. It is time too that wood-producing "dirt foresters" recognized more generally the possible values that future generations of silviculturists may place on the existence at that time of adequate samples of comparatively undisturbed natural forest types widely representative of the various ecosystems, Chapman (1947), Heiberg (1947), Rowe *et al.* (1960) and Shanklin (1957 and 1958). These proposed special reserves, limited in size, may often be established within existing national or provincial parks or wilderness areas, provided there is a clearly established policy for their protection and proper use. Even now, especially in the deciduous forest regions of eastern United States, many natural forest types can no longer be found for the ecological studies desirable as a foundation for a sound silviculture. Once logged without previous studies of composition and ecological properties, rare forest types containing unusual or unique genotypes may be lost.

IN CONCLUSION

Foresters must put as much emphasis on protecting and where possible improving the productivity of the lands which are made accessible and which are cut-over as they do on logging efficiently. There is an obligation to make much more serious efforts in this direction, even if it means lower immediate cash returns in the form of stumpage, logging profits and taxes are available from the initial harvest. Of course the forester may not be in a position to control cutting, but he can at least make known the probable consequences to the best of his ability. In addition, much more aggressive research and greater educational efforts must be undertaken in order to realize the highest value from our great spruce forest.

It must be recognized that the real resource is the forest soil and its continued productivity, not the present merchantable stumpage (Rostlund, in Haden-Guest *et al.* 1956). The highest quality sites should be promptly

restocked at suitable spacing with the best genotypes available of the species best fitted for the specific location. This should be the objective whether natural or artificial regeneration methods are indicated for the particular site. Furthermore, means must be found to capture the attention and stimulate the imagination of the public and industrial leaders in order to provide the long-term investments necessary for maintaining and increasing the forest soil productivity of the Canadian Spruce Forest. In practical terms this means finding the capital and other funds for the required investment in research, education, initial surveys, development roads, and for the current needs in forest protection, regeneration and crop tending measures. In this connection, the ideas presented by Streyffert (1960a and 1960b) and Vaux (1954) are quite pertinent.

The growth capacity of the vast Canadian Spruce Forest represents our greatest forest resource or "production plant." Its efficient maintenance and gradual improvement warrant the concentrated attention of all Canadians, but especially of professional foresters. With an optimistic view of the future and faith in our abilities these vast woodlands should minister in perpetuity to the material and aesthetic needs of great numbers of future North Americans and other peoples of the world.

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